



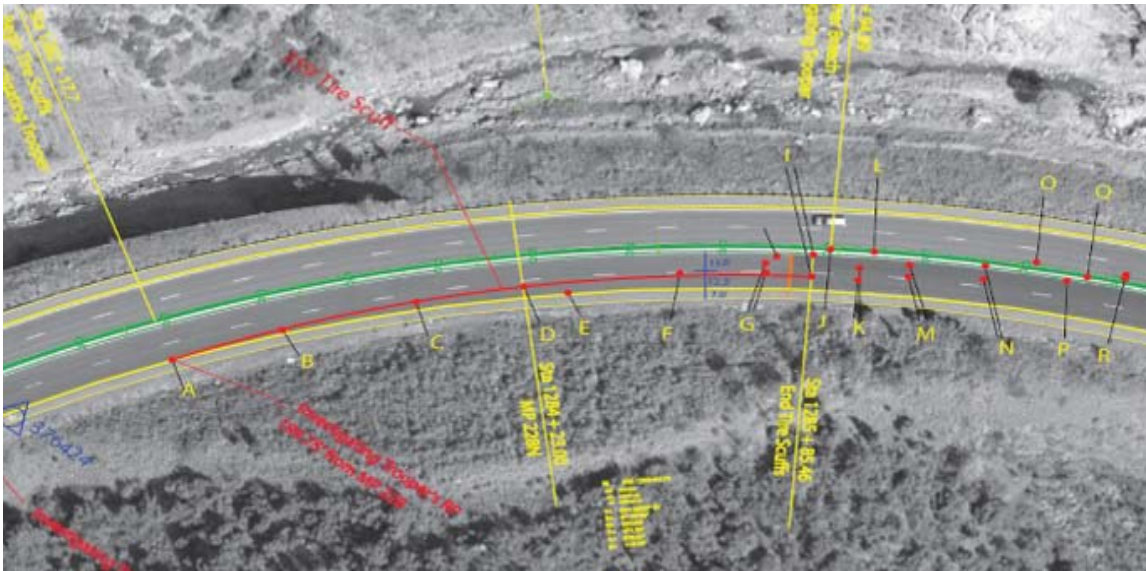
ARIZONA DEPARTMENT OF TRANSPORTATION

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Photogrammetry Section

# Mapping Services Manual

## Photogrammetry & Mapping Services



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# 1.) The Photogrammetric Process

## ***A description of our photogrammetric capabilities and project management considerations.***

### Introduction

The products and services discussed in this document, namely, aerial photography, photo enlargements, digital mapping, Digital Terrain Models (DTM's), and orthophotos are closely related. Although each may be used independently, they are most often used in conjunction with one another. It is important that Arizona Department of Transportation personnel requesting the products have an appreciation of the technology and intermediate steps involved in their production. This chapter briefly describes the photogrammetric process within ADOT.

### Product Requests

Requests for aerial photography, mapping, orthophotos and DTM services should be made as early as possible. This provides adequate production time and allows for unpredictable delays, such as survey schedule for control and paneling, permits for access and unfavorable weather and lighting conditions that prevent or delay the acquisition of aerial photography. A completed project from photography to final mapping product can take several months from start to finish. A diagram of the area to be photographed should be included with each request.

### Coordination of Flying

The Photogrammetry and Mapping (P&M) Service will review product requests, resolve any questions, prepare a flight plan diagram and related documentation, and arrange for the flight schedule for the acquisition of aerial photography.

## Survey Paneling

Paneling refers to the placement of a large "+" or other symbol, (see below), that will be visible on the aerial photography. Although paneling is not mandatory, it is highly recommended. In general, the placement of panels offers the following advantages:

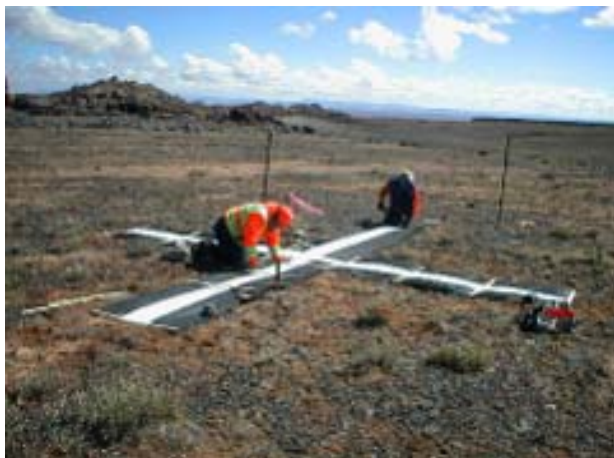
1. The ability to select control points in areas where no photo identifiable points exist.
2. The elimination of error caused by misidentification in the field of selected photo control.
3. The ability to begin field horizontal and or vertical control before photography is flown and delivered.
4. Ease of pilot/photographer identification of the project.

The P&M Service selects the locations at which panels should be placed and plots their locations on flight line diagrams. (See Figure 1 in appendix "A" for a sample.) Placement of panels is coordinated with the flying of photography so that a minimum amount of time elapses after panels are placed until the project is flown.

**Standard Paneling Procedure:** The standard procedure is to have pre-selected control points located, surveyed, and paneled in advance of the photography. Where applicable use panels that can be painted or taped on a paved surface. These can be placed quickly and require minimal maintenance. These panels will generally be sufficient for horizontal control.

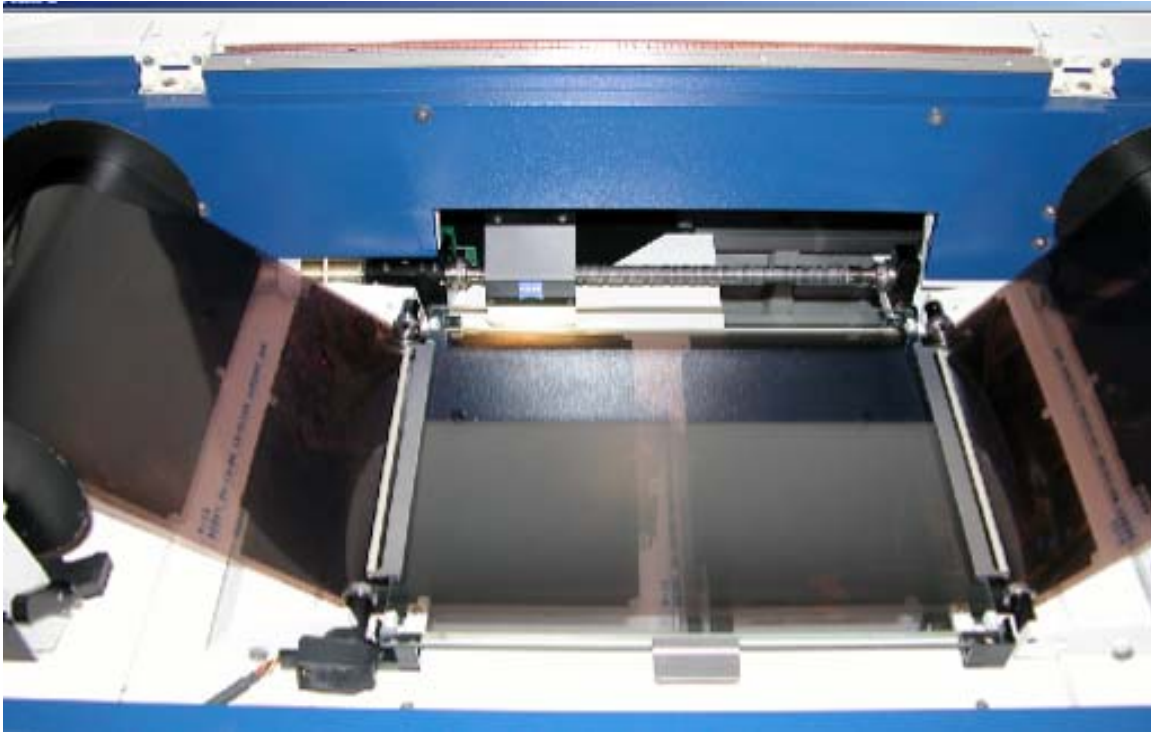
Additional photo wing points will be needed to complete the vertical control. Under the standard paneling procedure points selected are located in appropriate places and are highly visible on the aerial photography and free from shadows.

**Optional Procedure:** An optional procedure that can expedite delivery of the photography involves not paneling a project and performing the control survey after the photography by photo identifying the necessary photogrammetric control. This procedure is recommended only for projects where time does not permit the placement of control and panels, but is not as reliable / accurate as the Standard Procedure.



## Receipt of Photos

After the aerial photography is flown, film is inspected for coverage, scale, crab, tilt and other factors, such as image quality and cloud cover. If found to be acceptable, the processed film rolls are scanned into TIFF image files for use on our softcopy workstations, (see below).



*Roll Feed Photo Scanner*

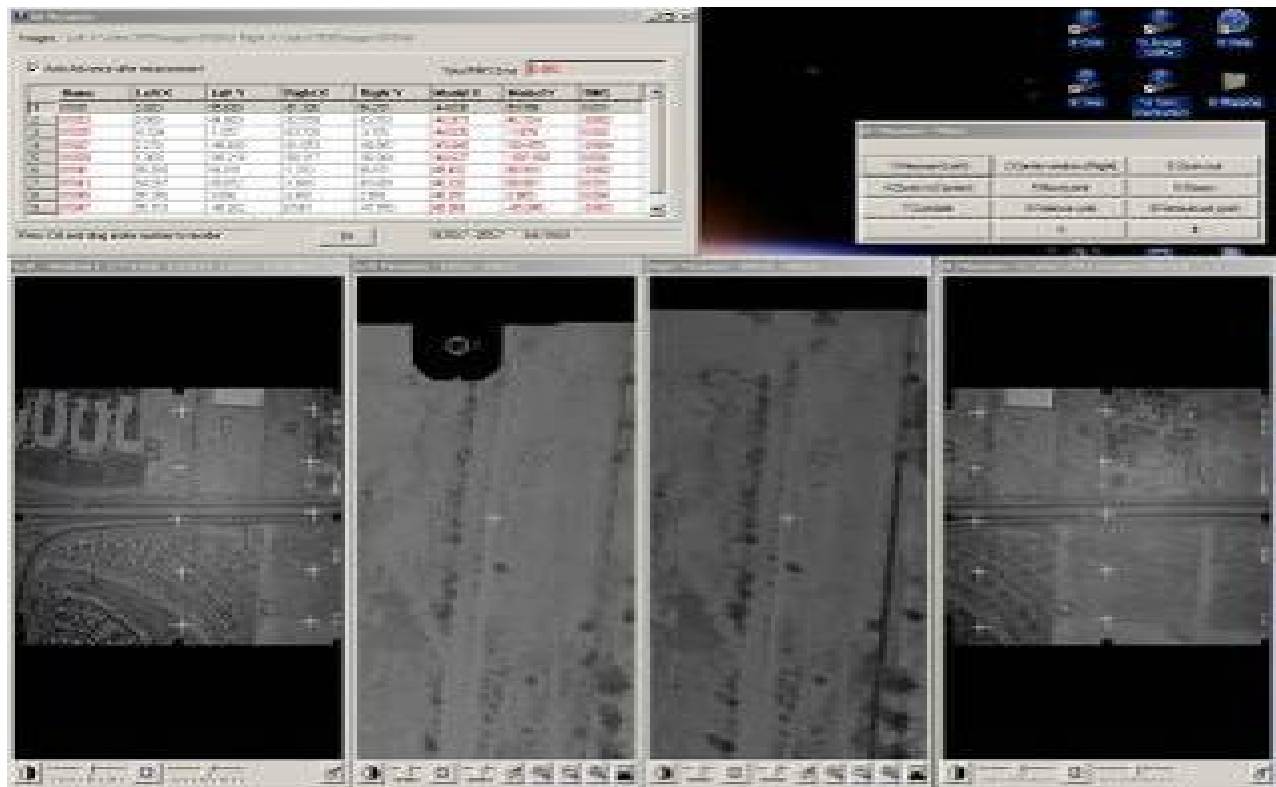
## Control Survey

The purpose of the control survey is to precisely measure the locations and elevations of panels in the area to be mapped. The Photogrammetrist selects the points to be surveyed. This selection is based on the aerotriangulation requirements, panel's visibility on the photos, and accessibility for field survey crews.

These points when marked on photographs or maps of the project are for flying the photo mission and for field survey crews to use in identifying and setting the panel at the appropriate site. Field survey crews then survey these points and submit the control data. The surveyed values are then used for controlling the horizontal and vertical scale during subsequent softcopy data collection. The control survey is based on the State Plane coordinate system.

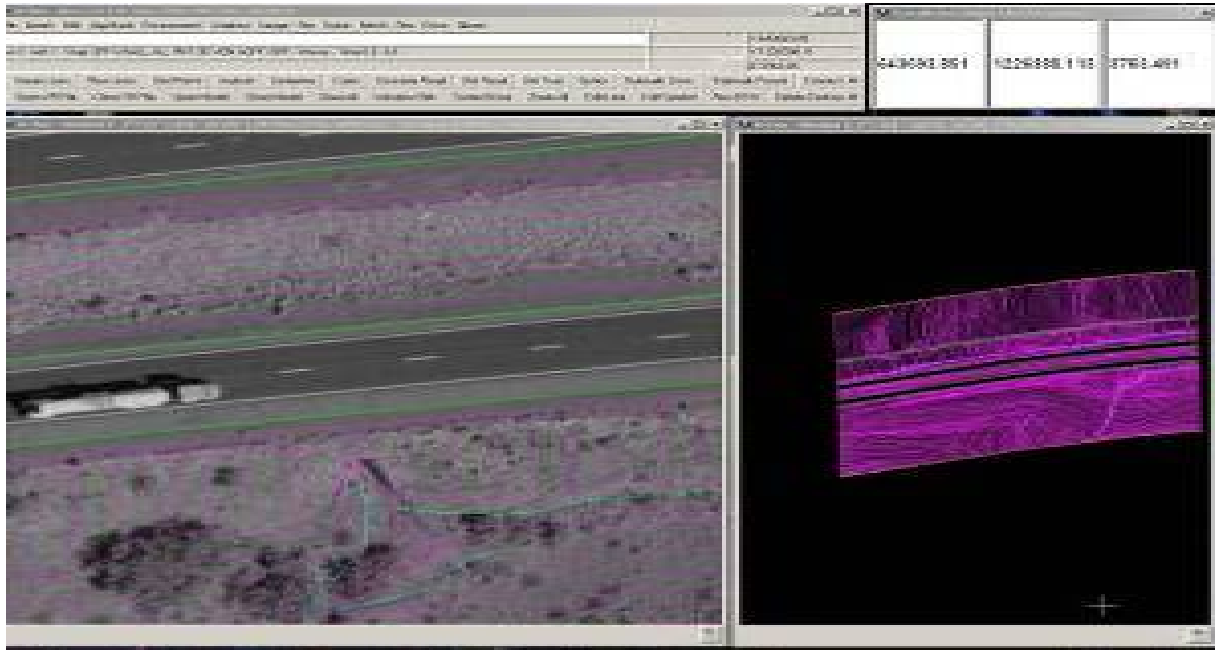
## Aerotriangulation

Aerotriangulation is a process that mathematically determines the x, y and z coordinates of any number of points in the object field by measurement of corresponding images on photographs and reference to coordinate values of a few fixed points in the object field (ground). The points are located in the field through the control survey. This process greatly reduces the number of points that must be field surveyed for mapping and also provides a means of verifying survey and stereocompilation accuracy.



*Typical Aerotriangulation Session*

# Stereocompilation



In stereocompilation, virtually all of the distortions inherent in aerial photography are removed, including those caused by aircraft tip and tilt as well as relief displacement. This is accomplished by viewing and orienting the photos stereoscopically to precisely adjust their 3D image to fit the coordinates of control points that were obtained through field survey and analytical aerotriangulation.

After proper orientation, digital terrain models and topographic maps can be produced by, in effect, compiling ground data from the three dimensional photo images. Stereo softcopy workstations are used which digitize and store data in modified state plane grid on different levels segregated by type of map feature, on the Department's CADD System. In general, all visible planimetric features that can be identified or interpreted are collected. Transportation related features are given special attention. All critical roadway and hydrologic features such as edge of pavement, centerline stripes, bridge decks, right of way markers, mileposts, pipes, inlets, culverts, catch basins, head and wing walls, etc are field surveyed prior to the mapping phase. These coordinates are converted into discrete points which are verified photogrammetrically as these features are collected. This gives an added level of quality control for the resulting data. All photogrammetric mapping currently done for the Department is delivered digitally in Microstation V8 Format either by the Photogrammetry Section or by commercial contractors.

Upon completion of the stereocompilation phase, the Microstation Design Files undergo a cartographic edit after which the final products are submitted to CADD Services for archiving with Engineering Records. The requestor is notified of completion and the information under which it is stored.

## Cartographic Edit

The cartographic edit phase is an office review of the completed map stereo data collection. It involves an examination of the data and a comparison with photos and other source materials. The cartographic edit phase does not add any field information to the map files. Data is checked for completeness, proper symbology, labels and file level assignment and consistency. Data finishing tasks, such as adding the state plane grid and additional text, are also accomplished during this phase.

## Digital Terrain Models

A Digital Terrain Model (DTM) is a mathematical model of the earth's surface formed by digitized three dimensional coordinates (x, y, and z). Data collection is performed on a stereo softcopy workstation through a process similar to mapping compilation. However, data is collected along specific terrain features that define the surface of the earth. These features will generally be changes in slope, crest of ridges, streams and civil works, such as roads, dams, canals, etc. Spot data will be added to this information to better define large areas of uniformity. Field data can also be added to help define critical features. This model is constructed and used on the Department's CADD systems with the Cardinal System's VR suite of photogrammetric design software. Once these files are compiled the editing staff converts them to Microstation V8 DGN format which can then be manipulated with Bentley InRoads ®. DTM's are an alternative to conventional contours since modern software can create contours from a DTM surface file. No separate compilation of contours will be performed on those projects for which DTM's are requested.

While the DTM is a mathematical model of the earth surface, it is constrained in its use the same as a topographic map. The data collected for the DTM will be for a specific scale and contour interval, i.e. (1" = 50', 2' CI or 1" = 200' 5' CI). The computer has the capability to produce whatever is requested within the limits of the program. However, the accuracy will still be only as good as that for which data was collected in the stereocompilation operation.

That is, data collected for 1"=200' at 10' contour interval can be used by the computer to generate a map of a scale of 1"=50' at 2' contour interval, but its accuracy will still be for the 1"=200' at 10' CI as it was collected. On the other hand, this same data can be used to generate a map at 1"=1000', 20' CI which will have the accuracy of the original data. Completed DTM files will be delivered to the user or consultant on CD or DVD media as applicable due to file / project size. Due to the large file sizes involved it is not feasible at this time to deliver digital data via the internet or through secure FTP.

## Standard and Scale-Ratioed Photo Enlargements

When standard black and white aerial photography enlargements are required (enlargements that do not have the scale accuracy of scale-ratioed enlargements), they can be prepared in house within 3-5 days after the negatives of the aerial photography are received.

Scale-ratioed enlargements provide better planimetric accuracy than standard enlargements by matching to field surveyed distances or measurements taken from a large scale map or other sources. Accuracy can only be assured between surveyed or measured points, with measurements generally being taken along the main feature. Scale-ratioed enlargements are not as accurate as a planimetric map and cannot compensate for photo distortion caused by terrain variations or aircraft tip and tilt. Black and white enlargements are prepared in-house; all color photo work is contracted for and will require additional time to process.

## Project Scheduling / Prioritization

All phases of the photogrammetric process are completed in accordance with time schedule priorities. These priorities and latest completion dates are used to establish an overall program priority for each project. This allows for photography to be evaluated and control to be selected on the basis of need.

The photo control layout is coordinated with the Engineering Survey Section. Individual project schedules are coordinated with the Engineering Survey Services to allow for the timely completion of each phase (survey, aerotriangulation, stereocompilation, edit and Digital Terrain Model) of the data collection. These estimates are closely monitored to assure that each project stays on schedule.

A mapping project typically takes from 10-20 weeks to complete after start of the control survey. Several steps can be taken to significantly reduce the length of time for the entire process. However this usually requires delaying other projects and is not a desirable practice. The most important step is to have the request well in advance of the need for mapping and in considering all survey and mapping needs for the project at this time so as to eliminate the amount of rework. If it is anticipated that mapping may be needed, photography should be flown so that it is available when mapping is required. If the photography has not been flown and mapping is needed quickly, use of the Optional Paneling Procedure (see Optional Paneling Procedure, page 2) may reduce the length of time that elapses between the acquisition of photography and delivery of the final product. For a single high priority project P&M Services can reduce the normal time for project completion by delaying lower priority projects.

## 2.) Aerial Photography

### DESCRIPTION

The aerial photography is taken with black and white or color film in 9 x 9 inch format. Generally the scale of the film negative is 1" = 250' or 1" = 300' for design scale mapping projects, and 1" = 1000' for planning scale mapping projects. Other photo scales may be applicable depending on the products desired; such as county mapping, ALISS, route records, oblique, etc. Photos are marked with the date of photography, photo scale, 4 digit P&M Job Number and flight strip and exposure numbers.

Photos are taken with 60% overlap between successive photos to permit stereo viewing. Block coverage (adjacent flight lines for wide-area coverage) also includes 30% sidelap between photo strips.

The requestor normally is provided with one set of contact prints of each project for their files. Other sets of contact prints go to the Photogrammetry and Mapping photo files, mapping consultant, (if one has been assigned to the project), etc. Extra copies can be made on request by using the Photo Work Request Form # 55-8402 R1/90 (Appendix A).

Although black and white photography is the standard product, color aerial photography may be obtained if there are special project requirements. Advance planning is critical in the acquisition of aerial photography. Requests should normally be made well in advance of need to allow for the coordination and scheduling of the various entities involved.

### USES

Aerial photographs can be used for general views of an area, preliminary design, public hearings or legal court cases; or updating and correction of county maps, hydrology studies, materials borrow pit quantities, or environmental issues; to make diapositives for stereocompilation of maps or digital terrain models (DTM).

### ACCURACY

The aerial photography has not been corrected for the anomalies that affect the photo scale. This means that there are scale differences throughout the photo, especially in rough terrain.

### DELIVERY

Contact prints of black and white photos will generally be available 3-5 days after the flight. Color prints will take 10 to 15 days after the flight date as these are made under contract.

### 3.) Photo Enlargements

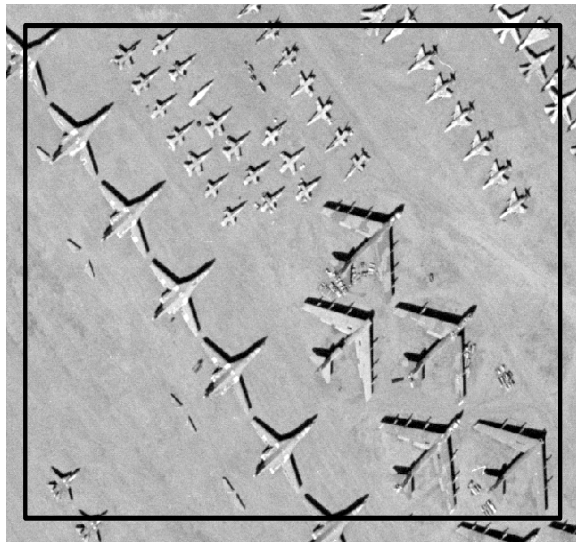
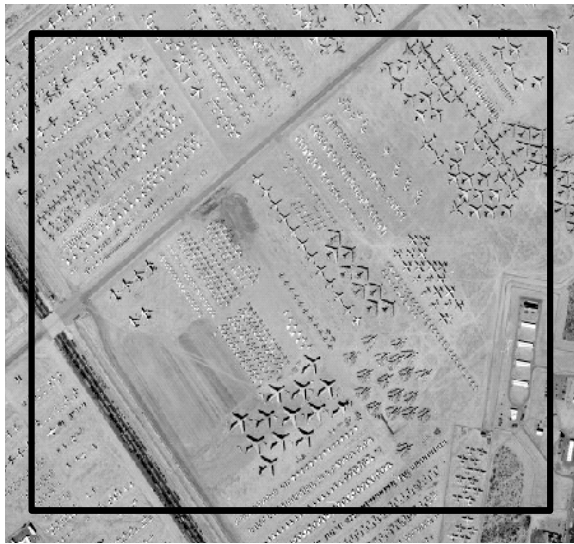
#### DESCRIPTION

Photo enlargements are black and white images reproduced on paper or mylar from the original 9 x 9 inch aerial film. Copies can be made up to 10x the scale of the film negative.

If an enlargement factor greater than 4.4x is required, the entire image of the 9 x 9 inch contact print will not fit on the maximum paper size of 40 x 40 inches, thus the enlargements will be limited to just a portion of the photo or made in sections. Because of the substantial overlap between consecutive photos within a single flight strip (60%), and sidelap between adjacent flight strips (30%), continuous coverage is obtained by ordering enlargements for alternate (all even or all odd numbered) photos in a flight strip.

Two types of Enlargements are available: Standard and Scale-Ratioed.

Standard enlargements are not scaled. An enlargement factor is used i.e. 2x, 3x, 4x, etc., up to 10x.



Scale-ratioed enlargements are scaled by comparing two photo identifiable control points, usually along a highway alignment, with a field surveyed distance or a measured distance on a large scale map for the same two points as provided by the requestor. This provides improved accuracy over standard enlargements.

## PHOTO MATERIAL

Enlargements are available on either photographic paper or transparent polyester film (Mylar).

Enlargements on photographic paper have a continuous tone emulsion which gives the sharpest image quality, these are not reproducible.

Enlargements on Mylar can be reproduced as diazo, (white print) or offset prints. The images may be half toned (broken into small dots) and may not be as sharp as photographic paper images. If annotations are to be made on the enlargement, the photo image can be subdued to enhance the legibility of the annotations. Mylar enlargements can also be stripped into 24 x 36 inch plan sheets.

## USES

<u>STANDARD</u>	<u>SCALE-RATIOED</u>
Public Hearings	Traffic Intersection Improvements
Legal Displays	Landscape Design
Guardrail Studies	Highway Plans Sheets
Traffic Intersection Studies	R/W Plan Sheets
Advance Engineering Studies	Preliminary Design Work
Environmental Studies	
Sign Location Studies	
R/W Plan Sheets	
Preliminary Design Work	
Transportation Planning Studies	

## DELIVERY

All photo black and white enlargements are made in house. Prints are normally available within 3 to 5 days after the requester examines the contact prints and submits a written request with the desired enlargement scale, and the material on which they are to be prepared. The Photo Lab Work Request Form No.A55-8401 R1/90, (Appendix A Figure 4), should be used.

## 4.) Digital Mapping

### Description

All photogrammetric mapping is compiled as digital terrain data for use with Microstation V8. Planimetric (2 dimensional) data files include all transportation and related features, and other cultural features visible on the aerial photography. Final products are graphic digital files.

These data files are for planning and design scale maps. Common map scales are for planning 1"=200' and design 1"=20', 1"=40' and 1"=50'. Aerial photography is flown at the altitude required to produce the map at the scale and contour interval desired.

In conjunction with the Department's use of the Bentley InRoads ® program, the Photogrammetry Section will collect future photogrammetric data as Digital Terrain Models (DTM). Data collected by this method will allow the designers or users with the InRoads ® program to provide the information they need, i.e. contours, x-sections, profiles, 3-D views, etc. The DTM mapping width can vary within the project and should be specified by the requestor.

### ACCURACY

All photogrammetrically produced maps or digital terrain data shall meet requirements as defined in the Reference Guide Outline-Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways prepared by the American Society of Photogrammetry and published by the U.S. Department of Transportation.

The requirements state:

- A. Coordinate grid lines or grid ticks and horizontal control points shall be plotted with 1/100th inch of true position.
- B. At least 90 percent of all well defined planimetric features shall be plotted within 1/40th inch of true position, and the remaining 10 percent shall be plotted within 1/20th inch of true position.
- C. At least 90 percent of all elevations determined from solid line contours shall be accurate within one-half the contour interval and the remaining 10 percent shall be accurate within one contour interval. Note that any contour that could be brought within this accuracy tolerance by shifting its location 1/40th inch (the allowable horizontal error) will be considered to be acceptable.
- D. At least 90 percent of spot elevations shall be accurate within one-fourth the contour interval, and the remaining 10 percent shall be accurate within one-half the contour interval.

**CAUTION:** These standards ARE NOT applicable if it has been decided to enlarge the map photographically, by computer, or by some other means.

## Current Technical Environment

The ADOT Photogrammetry Section currently utilizes ten HP xw8400 workstations with Microsoft XP Professional SP2. All data is collected using Cardinal Systems VR Two Softcopy Photogrammetry Suite. Once the data is collected and checked stereoscopically the files are translated into Bentley Microstation V8 DGN format for final editing and delivery.

## SYMBOLIZATION

Feature selection and symbolization will be placed using ADOT standard graphical elements for either design or planning scale maps for use on ADOT's CADD System. These are available either from the ADOT website at <http://www.azdot.gov/Highways/cms/index.asp> or may be obtained via a request placed through the [ADOT Photogrammetry Section](#).

## COMPILATION SPECIFICATION

All photogrammetric data is collected in accordance with the following specifications. Map features will be defined, positioned, and symbolized according to these specifications during the data collection and editing process. All 3D data and cultural features are measured and collected manually. Auto-correlated data points and stream digitized line strings are not allowed. Each stereo model will correspond to a single 3D file containing all planimetric and terrain features.

## FINAL PRODUCTS

Photogrammetry and Mapping services will provide the requested project as a digital file in Microstation V8 DGN format. The file will provide information for topographic maps for accuracies needed for planning or design purposes. At the completion of a project, all design files are written out to computer file. The computer tape archive directory contains a listing of the tape number for the archived projects. Files may be accessed using the file names indicated in the completion / transmittal memo.

The P&M Service does not provide velum plots as final products. [CADD Services](#) has the capability and are responsible for generating any velum plots needed, and / or plots on contract plan sheets.

If the mapping is to be used by a consultant with a CADD system other than Microstation V8, the digital data must be translated. ADOT does not translate, or arrange for the translation of Microstation V8 Design Files into digital files of another format (e.g., AUTOCAD). Translation of the delivered Microstation V8 Design Files into another format with the use of programs run by third party firms is the responsibility of the consultant.

## DELIVERY

Finished data can normally be delivered within 10 to 20 weeks depending on project size and complexity.

## 5.) Digital Terrain Models

### DESCRIPTION

The data collection philosophy underlying Digital Terrain Model (DTM) compilation is different than that used for standard contour or cross section compilation. A photogrammetric DTM is constructed from "breaklines", which are lines that define a change of slope or terrain character, and spot elevations. During DTM data compilation, the softcopy stereoplotter operator will digitize the locations and elevation of enough breaklines, vertices, and spot elevations to form an accurate mathematical model of the terrain. The Bentley InRoads ® software can access the DTM to generate contour lines, cross sections, profiles, slope vectors, or shaded relief views.

A digital terrain model can be requested with or without accompanying planimetric mapping. The area of DTM coverage can be smaller than that requested for planimetric mapping. The width of the band of coverage can vary within the project and should be specified by the requestor.

Using Bentley InRoads ® software package, contours, cross sections, profiles, and other terrain displays and data can be generated from the DTM. This data can be sent directly into the design options of the CADD design programs, (Appendix A Fig. 2).

For users with limited access to the CADD System, InRoads ® can be used to extract and format cross section data from a DTM for input into other formats, i.e. ASCII. After the design phase of a project, construction cross sections can be generated from the DTM along the design centerline, eliminating the need for field collected sections, or recollecting them photogrammetrically.

The generation of profiles, cross sections, and other terrain data using the DTM is the responsibility of the requestor. The P&M Service will provide assistance, however, when requested to do so.

### USES

#### **Facilities Design**

InRoads ® design DTMs are the fundamental raw data for ADOT's automated design systems. For projects to be designed with InRoads ® design software, photogrammetry can be used to produce properly constructed, highly accurate, and cost effective DTMs. Contours, cross sections, profiles, and spot elevations can be extracted from a DTM along any number of trial alignments during the design process. Once a cross section database is established from a DTM, an ASCII report file can be generated.

## **Pre-Construction Cross Sections**

After the design process is complete, a new set of cross sections can be produced from the DTM for use by Construction. These sections can be extracted precisely from the final design alignment at the exact stations and intervals required by Construction.

The properly constructed photogrammetric DTM is suitable for determining earthwork payment quantities as well as preliminary design quantities.

## **ACCURACY**

The photogrammetric DTM data collection process provides accuracy to meet the needs of most users. The critical consideration for a DTM user is not the vertical accuracy of the individual measured points from which the DTM is constructed, but the vertical accuracy of any randomly selected point as derived from the DTM.

For design scale projects, point elevations derived from photogrammetric DTMs on hard surfaces will be accurate to within 0.2 feet of true elevation at the one standard deviation level. Some projects may require greater vertical accuracy in specific "critical" areas of the DTM. For such needs, a combination of field survey and photogrammetric data can be used to build the DTM. The field survey data, in the form of breaklines and some point data, as x, y, z is collected to define the project features where vertical accuracy is most critical. These critical features could be, for example, bridge approaches, culverts or other drainage structures, or the road centerline and edges-of-pavement. This survey data is transferred to the Photogrammetry Section in the form of Intergraph 3D design files. Compilers begin with this graphical data and complete the DTM around it using cost effective analytical stereocompilation techniques. With this combination method, design and construction engineers get DTMs with the cost effective aerial extent they want, and the high accuracy they need.

**CAUTION:** DTMs built from contour or cross section data without breaklines may have inconsistent accuracy. Cross sections generated from such DTMs may be unsatisfactory for many design applications.

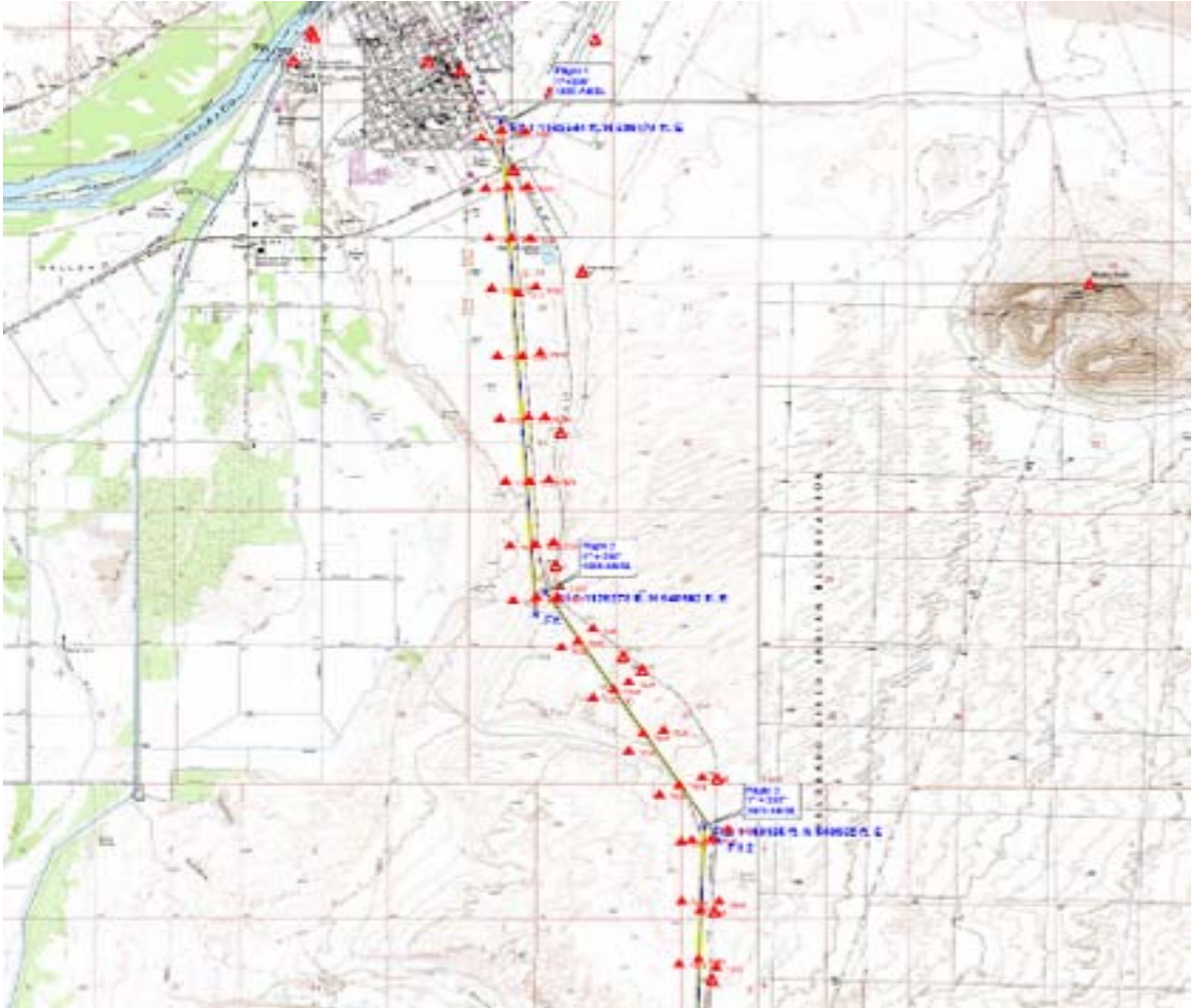
## **FINAL PRODUCTS**

Requestors will be provided with a DTM in the form of Triangulated Irregular Network (TIN) files, (Appendix A Fig. 3). This is the numerical surface file format used by InRoads ®. A planimetric file of 2D data will also be available for design use.

## **DELIVERY**

A finished DTM and planimetric map files can normally be delivered within 10 to 20 weeks depending on project size and complexity.

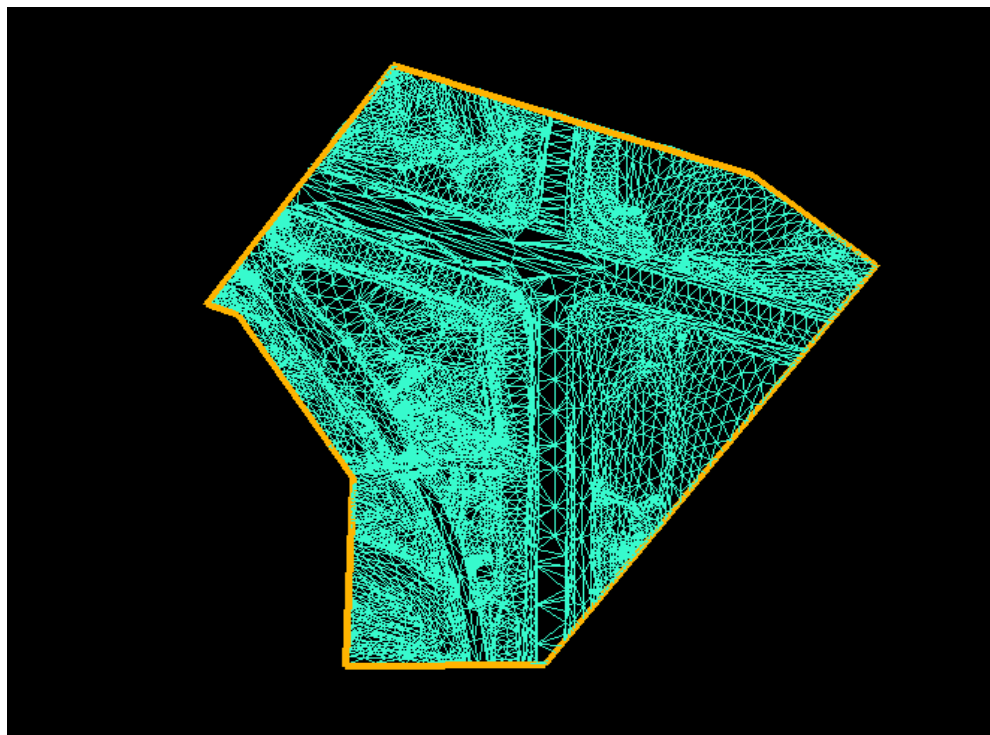
## Appendix A



*Figure 1 – Typical flight plan diagram*



*Figure 2 – DTM Breakline File*



*Figure 3 – Triangulated DTM*

Print Form

Email Form

Desk Reviewer: \_\_\_\_\_  
 Log Number: \_\_\_\_\_

**PHOTO LAB WORK REQUEST**

ARIZONA DEPARTMENT OF TRANSPORTATION  
**Photogrammetry and Mapping Services**  
 2739 E. Washington St. MD 203P  
 Phoenix, AZ 85034  
 Contact: Stuart Chase 602-712-8578  
 or the Photo Desk at 602-712-8561

Date: \_\_\_\_\_  
 Org. Name: \_\_\_\_\_  
 Job Location: \_\_\_\_\_  
 Requested By: \_\_\_\_\_  
 Mail Drop: \_\_\_\_\_  
 Phone Number: \_\_\_\_\_

**TO BE FILLED IN BY EMPLOYEE ORDERING**  
**(USE BLACK INK)**
→

ORG CODE	TRACS NUMBER	ACTIVITY

**AERIAL PHOTOGRAPHS (10" X 10")**

MATERIAL (MAT'L): PAPER = P, DIAPOSITIVE = D

JOB NO.	FLIGHT	EXPOSURE NOS	PHOTO DATE	PHOTO SCALE	ROLL NO.	QTY EACH	MAT'L	TOTAL QTY

**ENLARGEMENTS**

MATERIAL (MAT'L): PAPER = P, MYLAR = M

JOB NO.	FLIGHT	EXPOSURE NOS	PHOTO DATE	PHOTO SCALE	ROLL NO	QTY EA.	MAT'L	ENLG X	TOTAL QTY

Remarks:

ORDERED BY (Complete Signature)

DATE

For additional services and comments or in the absence of Mr. Stuart Chase, please contact Marwan Aouad, P.E.,  
 Photogrammetry and Mapping Manager at 602/712-8578 or via email [maouad@azdot.gov](mailto:maouad@azdot.gov)

*Figure 4*  
*Photo Lab Request Form – Internal*

# Glossary

**Aerotriangulation (AT or Bridging)** – Triangulation for the extension of horizontal and/or vertical control accomplished by means of aerial photographs. Includes such procedures as stereo triangulation, radial triangulation and analytic triangulation.

**Analytic Point** – A point added to each neat model to produce adequate horizontal and/or vertical control and to eliminate a photo control target that otherwise would have required field control surveys. Also known as an artificial point or “pug” point.

**Basemap** – Existing maps and/or photography used for the purpose of planning mapping extents and requirements.

**Block** – A set of flight lines processed simultaneously to cover an area not possible with one flight line.

**CADD** - Computer-aided drafting (CAD) technology was first introduced in the mid 1960's as a tool for the production of drawings without the use of traditional drafting tools. The drawings were created and displayed by manipulating graphic elements on the computer screen instead of drawing them by hand. Engineering design capability was added to many of the CAD programs and thus the name was changed to Computer-Aided Design and Drafting (CADD).

**Crab** – The condition caused by failure to orient the camera with respect to the track of the airplane due to side winds.

**Design Cube** - When working in MicroStation, you are working within a defined and finite "universe". This "universe", known as the MicroStation drawing plane (drawing cube in 3D) has a fixed size based upon the way MicroStation stores the coordinates of lines, points, and other elements in the design.

**DGN** - DGN (also known as RDL) is a file format common to Intergraph's MicroStation and Interactive Graphics Design System (IGDS) CAD applications running on Intergraph workstations and PC's.

**Digital Terrain Model (DTM)** - A computer graphics software technique for converting point elevation data into a terrain model displayed as a contour map, sometimes as a three-dimensional "hill and valley" grid view of the ground surface.

**Feature** – Map graphic features or elements can be classified as points, lines, areas, or "raster." In GIS, these features are grouped together to form more complex objects such as "networks" of streams or roads, three-dimensional terrain "surface," and multi-polygon regions.

**Image** - A graphic representation or description of an object that is typically produced by an optical or electronic device. Common examples include remotely sensed data such as satellite data, scanned data, and photographs. An image is stored as a raster data set of binary or integer values representing the intensity of reflected light, heat, or another range of values on the electromagnetic spectrum. Remotely sensed images are digital representations of the earth.

**Level** – CADD technology treats digital data as electronic drawings that are basically made up of graphic elements organized into “layers” or “levels”. Each type of graphical element such as roads, buildings, DTM elements are assigned to separate “levels” which facilitates manipulation or isolation of these elements.

**Mosaic** - An assemblage of overlapping images, whose edges have been matched to form a continuous representation of the ground surface.

**Orthophoto** - Correction applied to aerial or satellite imagery to account for sensor tilt and terrain-induced distortion. Orthorectification requires an image and its sensor model, and a Digital Elevation Model (DEM) for the area of the image.

**Photogrammetry** - The system of gathering information about physical objects through aerial photography and satellite imagery.

**Stereoscopic** - Pertaining to the use of binocular vision for observation of a pair of overlapping photographs or other perspective views, giving impression of depth.

**Topographic Map** - A map depicting ground elevations through either contour lines or spot elevations. The map represents the horizontal and vertical positions of the features. It is a graphic representation delineating natural and man-made features of an area in a way that shows their relative positions and elevations.